Effect of Crown Scorch on Survival And Growth of Young Loblolly Pine

Thomas A. Waldrop and David H. Van Lear

ABSTRACT. Unthinned, pole-size loblolly pine (Pinus taeda L.) *plantations in the South Carolina Piedmont were burned at different seasons under minimal wind conditions to evaluate the effects of fire intensity on crown scorch. Needle drop, an indicator of crown scorch, was significantly greater on areas burned with medium- to high-intensity fires than on unburned plots. There was a direct relation between bark char height, beyond a threshold value of 3 feet, and crown scorch. Scorched needles fell within three weeks following fire. Moderate crown scorch had no detrimental effects on survival and growth of trees in the upper crown classes. Complete crown scorch resulted in the death of 20 and 30 percent of trees in the codominant and intermediate crown classes, respectively.*

Crown scorch of crop trees often results from prescribed fires in pine plantations where flame heights and/or convection heat becomes concentrated around the live crown. Variation in wind, fuels, fuel moisture, and relative humidity make crown scorch a common phenomenon even in well-administered burns. Cooper and Altobellis (1970) and Van Wagner (1970) report that crown scorch, rather than damage to the cambium, is the principal cause of mortality in pines after a fire.

Despite the frequency with which scorch occurs and its importance to vigor, little work has been done relating fire intensity to the degree of crown scorch. Van Wagner (1973) found that the height of scorching in the crown is a geometric function of fire intensity in northern pines. He also stated that only fires of low intensity are sure to cause no crown scorch above 25 feet from the ground. Villarrubia and Chambers (1978) found that crown scorch was more severe in lower crown classes in loblolly pine.

Storey and Merkel (1960) noted that degree of crown scorch seems to be the best indicator of potential mortality in longleaf (*P. palustris*) and slash (*P. elliottii*) pines. Mature red (*P. resinosa*) and white (*P. strobus*) pines have a 50-percent chance of surviving the loss of three-quarters of their foliage (Methven 1971). Villarrubia and Chambers (1978) found little mortality in loblolly pines whose crowns were almost completely scorched except for foliage on branch tips. Trees with a slight amount of crown scorch had significantly greater diameter growth than unscorched trees, a fact attributed to death of lower noncontributing limbs. Kimber (1978), working with 40-year-old eucalypts, also noted that scorching of crowns increased diameter growth. He concluded that scorching regenerated a more efficient crown and reduced seed production, thereby allowing increased growth rates.

Air temperature in the crown generated by the fire is a major factor determining the degree to which pine needles become scorched. The temperature reached at any height in the convection column above a fire depends on the intensity of the heat source, the ambient temperature, and the wind speed (Van Wagner 1973). Lotti (1960) stated that wind speeds of 1 to 7 miles per hour at breast height in loblolly pine stands were sufficient to carry heat through the stand at an oblique angle which would reduce danger of crown scorch.

In this study, the relationship between fire intensity, as indicated by height of bark char, and crown scorch in young unthinned loblolly pine plantations was evaluated. Patterns of needle drop following prescribed fire were observed and mortality and growth of trees in different crown classes were related to degree of crown scorch.

MATERIALS AND METHODS

Plots were established in five loblolly pine plantations on the Clemson University Experimental Forest in a randomized complete block design to relate fire intensity to crown scorching. Stands were unthinned 17-year-old plantations on level or gently sloping terrain. Density ranged from 827 to 1,012 trees per acre with basal area ranging from 210 to 220 feet per acre. Average height of all trees in each stand ranged from 62 to 69 feet while the average height to the lowest live branch of dominant and codominant trees was 25 feet. A one-fifth acre plot was burned in each plantation in June, August, and October of 1979. Temperatures were in the lower 80's for the June and August burns and in the upper 60's for the October burn. For all burns, the relative humidity was between 40 and 45 percent; wind speeds measured outside the stand were 0 to 2 miles per hour.

Needle drop, an indicator of the degree of crown scorch, was observed after each burn. Two wooden litter traps, 1 square yard in size, were randomly located in each burned and control plot immediately after the fire. Control plots were located within the same stand as the burned plots so that differences in needle drop could be attributed to fire rather than variations in precipitation, wind, or season. Pine needles were collected from traps in burned and control areas 1, 2, 3, 4, 6, and 8 weeks after each of the three fires. A split-plot randomized complete block design was used to detect weekly differences in needle drop between burned and control plots. Treatments included June, August, and October burns, and three controls, *i.e.*, one for each burn. All treatments were replicated in each of the five plantations, while time since burning was used as a subplot effect.

Differences in fuel conditions and season of burning resulted in variation in fire behavior within and among plots making it possible to relate bark char height to needle drop. Average bark char height on four or more trees closest to each litter trap was used as an indicator of the intensity of the fire in the immediate area of the trap. Fire intensity associated with each trap was categorized as unburned, low (bark char height of 3 feet or less), medium (4 to 6 feet), or high (over 6 feet). These categories represent fire intensities of 0, 1 to 90, 91 or 235, and over 235 BTU per second per foot, respectively, as estimated by Byram's fire intensity-flame length relationship (cited in Brown and Davis 1973).

To adjust for differences in needle drop due to season, precipitation, or rainfall, the average weight of needles that fell in the unburned control areas after each burn was subtracted from the weight of needles that fell in each trap of the corresponding burned areas. The average difference in needle drop was then determined for each bark char height by 1-foot increments.

In the summer of 1980, one year after the first burn, a survey was conducted to determine the mortality rate of trees with various degrees of crown scorch in each crown class. Visual estimates of five categories of crown scorch were used as

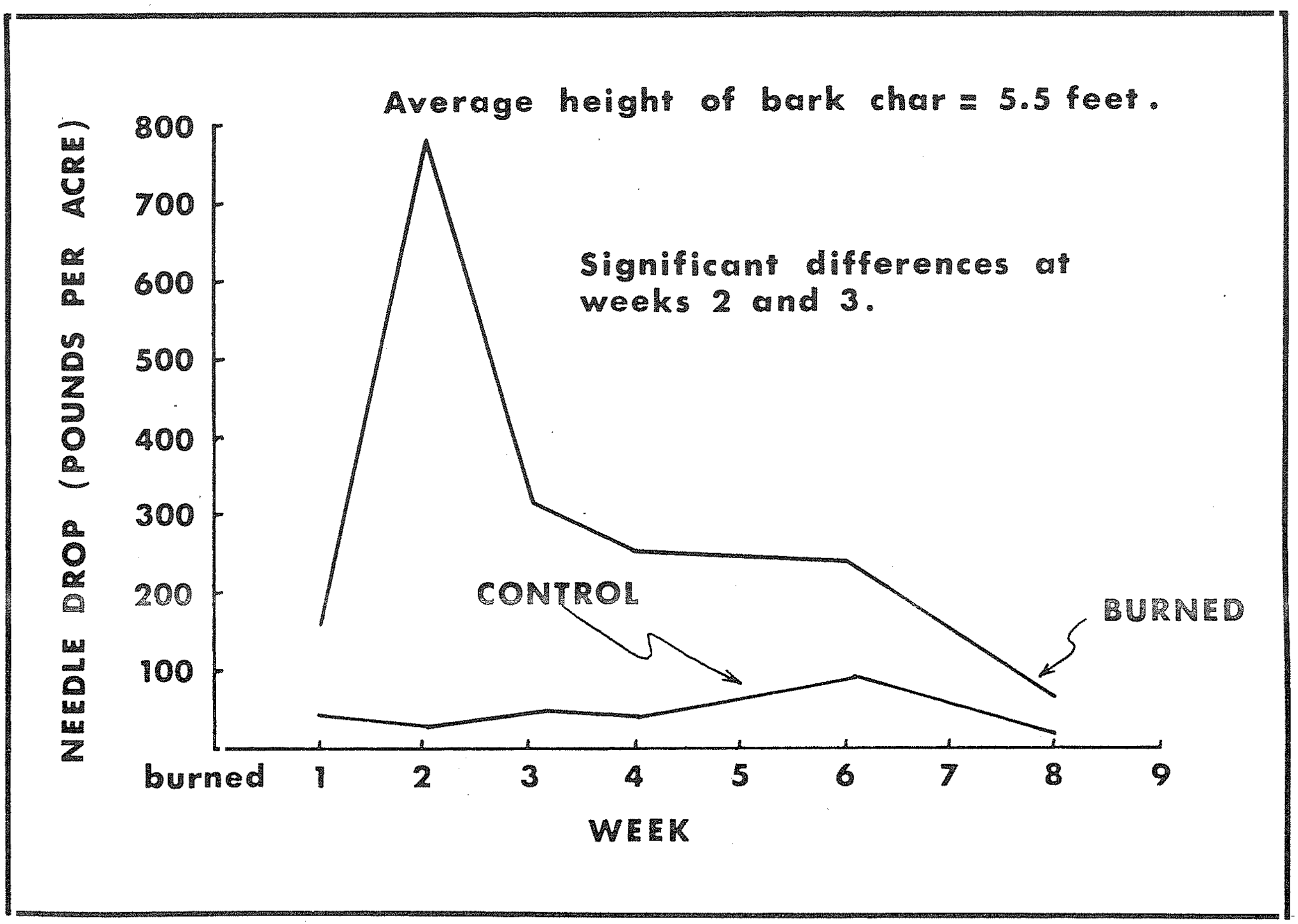

Figure 1. Needle drop patterns for burned and control plots following a June fire.

suggested by Villarrubia and Chambers (1978). These were: (1) no crown scorch; (2) less than one-third of the needles entirely scorched from fascicle to tip; (3) one-third to two-thirds of needles scorched; (4) all needles scorched, and (5) all needles and branch tips scorched. Ten trees in each crown class-crown scorch category were randomly selected and tallied as being alive or dead. Crown class was defined according to Smith (1962).

After the 1980 growing season, 25 cores were extracted from dominant and codominant trees in areas burned at each of the four fire intensities. The width of the last two growth rings was measured to determine diameter growth for the 1979 and 1980 growing seasons. Analysis of covariance was used to determine if fire intensity affected diameter growth of surviving trees in the growing season following the fire. Diameter growth for the year before burning was the covariable used to adjust for inherent differences in growth rate among trees.

RESULTS

Average char height for the June burn was 5.5 feet. Differences in the amount of needle drop between burned and control plots occurred during and after the second week (Figure 1). Scorched needles remained on the tree for at least 1 week with the majority falling by the end of the second week. Needle drop was significantly higher on burned plots than controls through the third week, after which no differences were detected. Estimates of needle drop differences are conservative because some cast needles may have been caught in the canopy.

The pattern of needle drop was similar for the August burn, which had an average char height of 5.7 feet. Scorched needles began dropping in the burned plots by the end of the first week, and needle drop remained significantly higher than controls through the third week (Figure 2). Peaks in both lines during the third week are attributed

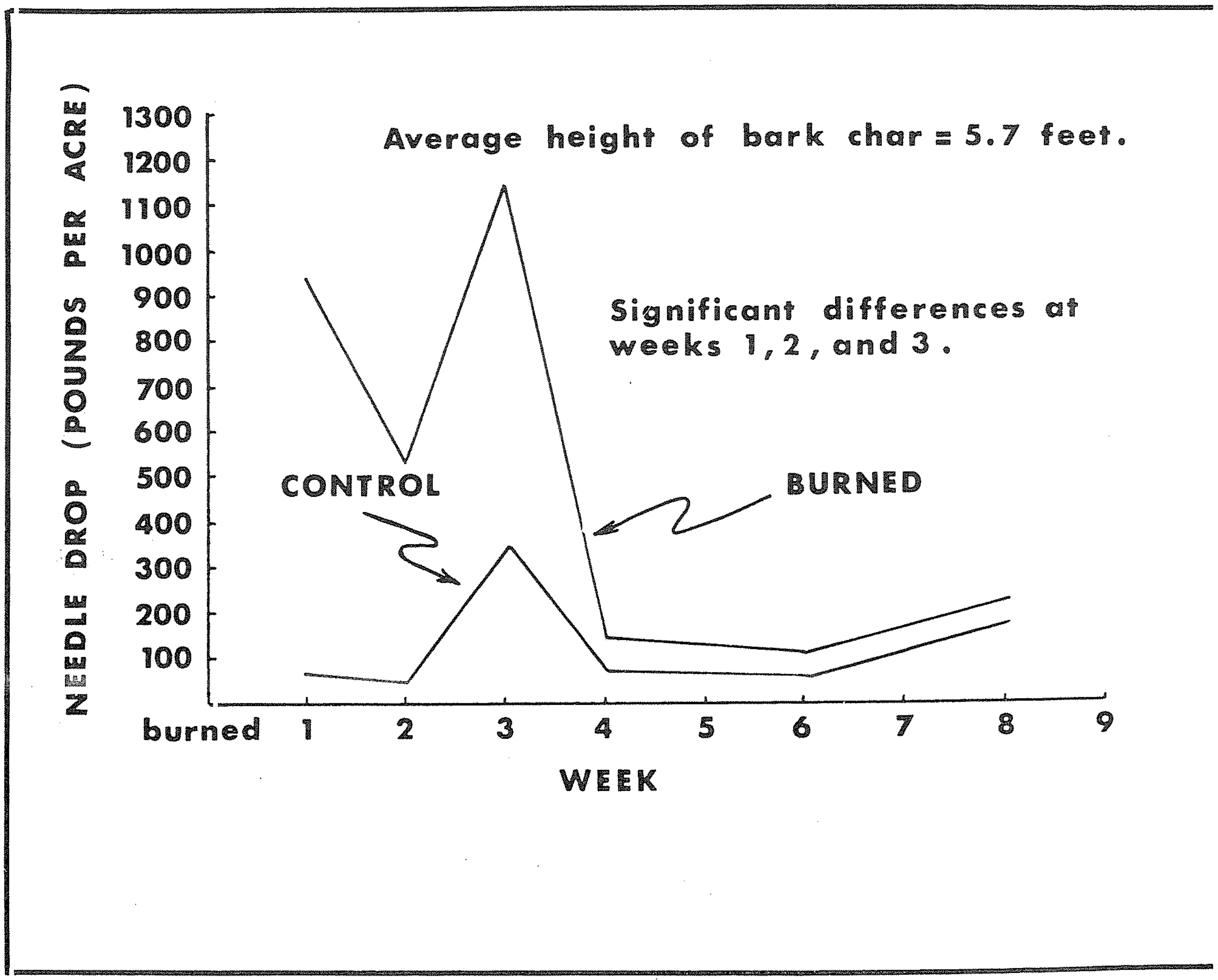

Figure 2. Needle drop patterns for burned and control plots following an August fire.

to high rainfall during that week (in excess of 4.5 inches). For the remainder of the collection period, no differences in needle drop occurred.

Significant differences in needle drop did not occur following the October burn (Figure 3). The average char height for this burn was only 2.2 feet. Crown scorching was not observed, indicating that needle drop was from natural mortality and abcission. Since needle drop in control areas paralleled that of burned areas, increased needle drop toward the end of this collection period was attributed to the onset of dormancy rather than scorching.

Needle drop was markedly affected by fire intensity (Figure 4). Needle drop for the first three weeks after burning appears to be the best indicator of crown scorch since this is when the majority of the scorched needles fell. During this period, there was little difference in the amount of needle drop in the control areas and in areas that had an average char height of 3 feet or less. This difference increased dramatically in areas where bark char ranged between 4 and 7 feet, indicating a significant increase in crown scorch. Needle drop also increased significantly in areas where bark char averaged 8 and 9 feet but the difference was not as dramatic. Reduced quantities of needles collected in these areas are probably due to scorched needles being carried away immediately in the convection column and immediate consumption of needles on the lower limbs by the fire. Both of these phenomena were observed but could not be quantified.

Since the crown canopies of all five plantations were completely closed, suppressed trees could not receive direct sunlight and were obviously in a declining state of vigor. This made determination of the effect of crown scorching possible for only the intermediate, codominant, and dominant crown classes. Mortality in these crown classes was

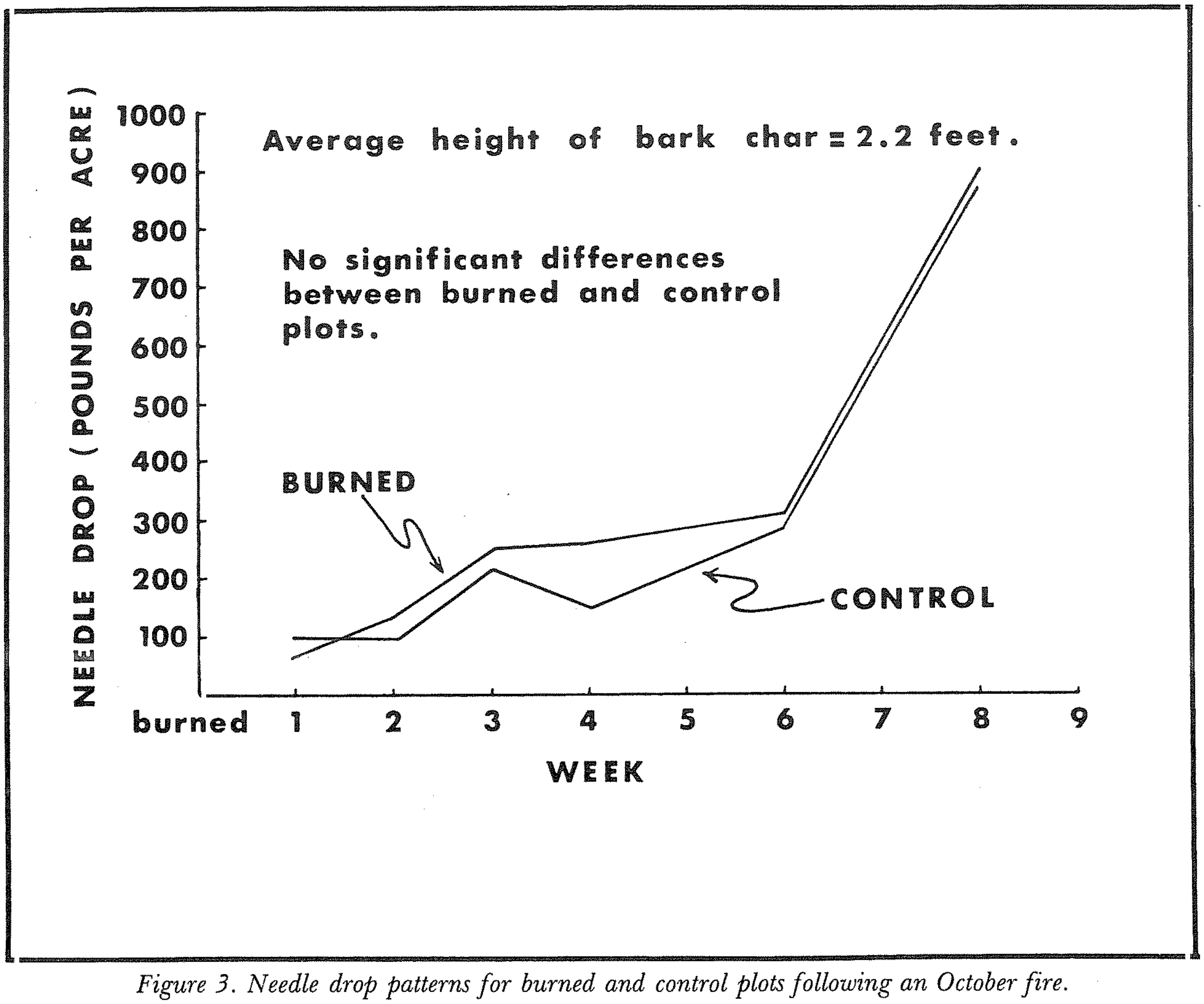

Figure 3. Needle drop patterns for burned and control plots following an October fire.

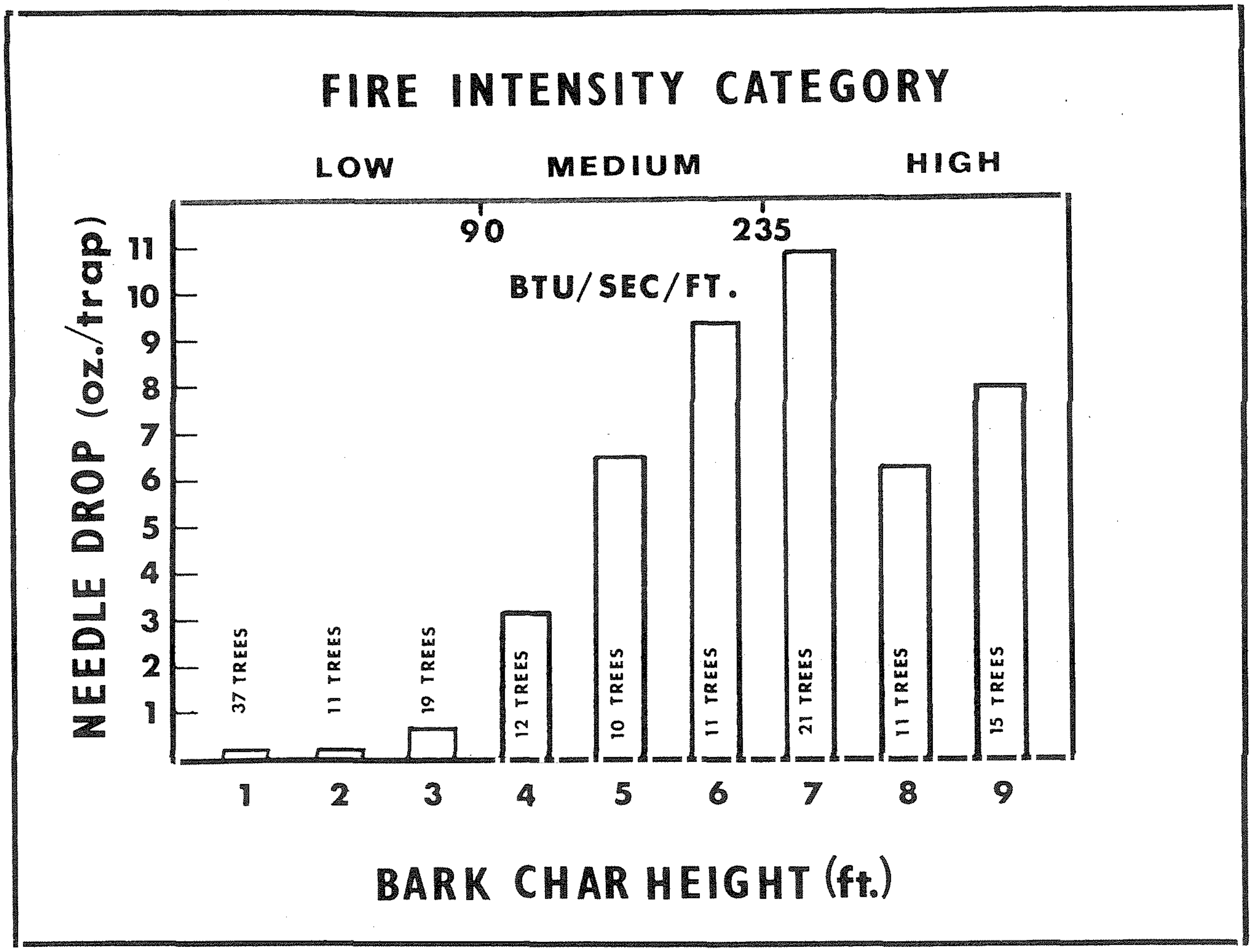

Figure 4. Bark char height and fire intensity vs. *needle drop three weeks after burning. Sample size for each bark char height indicated.*

low, being observed in only the intermediate crown class and in *completely* scorched codominants (Table 1).

Fire intensity had no effect on diameter growth of dominant and codominant trees for the year following burning. Postburn diameter growth nearly equalled preburn growth for low and medium intensity burns. However, the lowest postburn diameter growth did occur where fire intensity, and therefore crown scorch, was greatest. Diameter growth in these areas the year after burning was only 0.39 inches. Although not sig-

Table 1. Mortality rates (percent) of various crown classes one year after being subjected to various degrees of crown scorch.

	Crown scorch category[1]				
Crown class	0	1	2	3	4
Intermediate	0	0	0	20	30
Codominant	0	0	0	0	20
Dominant	0	0	0	0	0

[1] *Crown scorch categories: 0 = no crown scorch*
1 = less than ⅓ of crown scorched.
2 = ⅓ to ⅔ of crown scorched.
3 = all but tips of branches scorched.
4 = complete crown scorch.

Table 2. Mean diameter growth per year of loblolly pines during the preburn and postburn[1] seasons.

	Fire intensity[2]			
	Control	Low	Medium	High
	Inches			
Preburn	0.43	0.45	0.47	0.42
Postburn	0.44	0.44	0.49	0.39

[1] Postburn means are adjusted for initial growth differences.
Low = bark char height of 3 feet or less.
Medium = bark char height of 4 to 6 feet.
High = bark char height of over 6 feet.

nificantly different, this was lower than the growth for the previous year (0.42 inches).

DISCUSSION

Fires of medium intensity in young, unthinned loblolly pine plantations increased needle drop, a measure of crown scorch, when burning was done in the spring and summer under minimal wind conditions. In contrast, low-intensity fires (bark char height of 3 feet or less) had no effect on needle drop. These findings agree with those of Van Wagner (1973), who concluded that low-intensity fires in red pine should not scorch needles 26 feet or more above the ground. Crown scorch was directly related to fire intensity for bark char heights averaging 4 feet and above in these plantations. If lower branches had been present, the needles on them may have been scorched by low-intensity fires.

The use of needle cast as a method of quantifying crown scorch may be less valuable in areas that have been burned at high fire intensities. Direct consumption of the needles by the fire or loss of needles in the convection column reduce the amount of needles falling into litter traps below the scorched trees.

Some crown scorch is apparently not detrimental to survival and growth of young pole-size loblolly pine. There was no mortality in either the dominant or codominant crown classes, except where codominant trees were completely scorched (all needles and branch tips scorched). Dominant trees that were completely scorched did not die. Diameter growth of trees subjected to even high-intensity flames was not significantly affected in the year following burning.

These results may be of practical importance when conducting prescribed fires in pole-size loblolly pine plantations. Low-intensity fires are relatively safe in terms of causing crown scorch even under minimal wind conditions. However, if a more intense fire is needed to achieve the goals of the prescription, fires of medium intensity may be used. Such fires may cause crown scorch, but generally will not reduce tree survival or growth rates.

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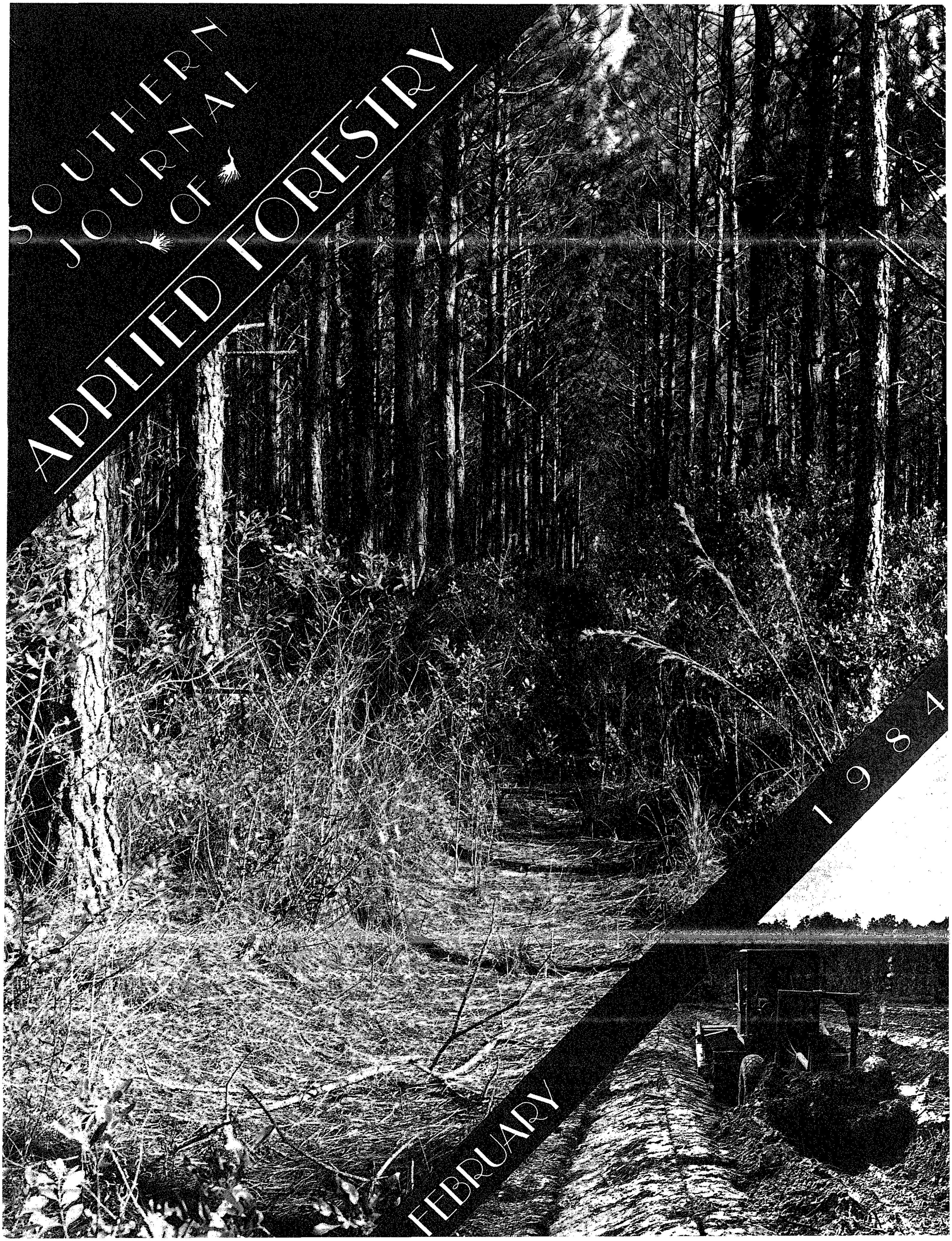

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COVER NOTE

Sixteen-year-old slash pine stand on high beds with a tractor and bedding rig (inset). Photographs courtesy of the Southeastern Forest Experiment Station, USDA Forest Service. See the article by K. W. Outcalt on page 29.

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Articles

Departments

MEETINGS

To insure its inclusion in this column information regarding meetings should be received at SAF National Headquarters two months prior to the next quarterly number of SJAF.

SYMPOSIUM ON THE LOBLOLLY PINE ECOSYSTEM (WEST REGION). March 20–22, 1984, Holiday Inn Downtown, Jackson, Mississippi. Symposium will summarize current technology on regeneration, management, and utilization of loblolly pine, and project the future of the species as an integral part of southern forestry. *Contact:* Dr. Tom Monaghan, Leader, Extension Forestry, P.O. Box 5426, Mississippi State, MS 39762 (telephone 601-325-3150).

33RD ANNUAL LSU FORESTRY SYMPOSIUM. April 4–5. Baton Rouge, Louisiana. Agroforestry in the southern United States. *Contact*: Dr. Mark K. Johnson or Dr. Norwin E. Linnartz, School of Forestry and Wildlife Management, Lousiana State University, Baton Rouge, LA, 70803. Telephone: (504) 388-4131.

1984 SAF-UNIVERSITY OF FLORIDA SCHOOL OF FOREST RESOURCES AND CONSERVATION SPRING SYMPOSIUM. April 10–11. Gainesville, Florida. Environmental regulations significantly affecting forest practices, particularly in Florida. *Contact*: Betty Peterson, Office of Conferences and Institutes, 1041 McCarty Hall, University of Florida, Gainesville, FL, 32611. Telephone: (904) 392-5930.

19TH EAST COAST SAWMILL AND LOGGING EQUIPMENT EXPOSITION. May 18–19. Richmond, Virginia. *Contact*: Mark Barford, Exposition Manager, P.O. Box U, Sandston, VA, 23150. Telephone: (804) 737-5625.

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